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Comparative Study on Effect of Buoys for Floating Sunlight Generation System with Numerous Buoys and Connection Beams

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In this paper, we investigate the effect of buoys on the response of a floating sunlight generation system. The floating structure comprises a large number of buoys linked by connection beams. We compared the responses of the structure by utilizing different buoy sizes. Wave forces on the buoys were calculated by employing the higher-order boundary element method. To evaluate the effects of the buoys, we compared the amplitudes and the distribution of wave forces acting on the structure for different scenarios. Stresses on the connection beams were analyzed in terms of both frequency and time domains, based on the results of wave load analyses. Connection beams were analyzed by the finite element method analysis. Through the analyses, we observed that the buoy size could reduce the stresses on the connection beam of the floating structure. To reduce this stress further, we proposed a floating breakwater and discussed the implications of such a method.

INTRODUCTION

With the depletion of preexisting resources such as oil and coal on the rise, renewable energies have come into the limelight. Among these energies, solar resources that have an infinite supply and nonpolluting properties have increasingly become the subject of research and development. In the case of sunlight generation on land, there are many problems when selecting a location, such as damaging scenery and thus conflicting with local residents. In particular, it is not easy to secure sufficient space for large-capacity development as a result of limited area. Interest in offshore sunlight generation is steadily increasing, as the location selection constraints are relatively low when compared with land selection. Offshore sunlight generation systems are also more efficient than inland generation because of sunlight reflected from the water being collected back to the solar panels.

There are various types of structures to support offshore sunlight generation systems. In this study, a large number of buoys support a floating structure. A hydroelastic analysis is necessary to take into account the characteristics of the structure, consisting of flexible connection beams. For large-scale structures such as a megawatt capacity class system, the hydroelastic analysis is especially needed. The change of structural dynamic characteristics as a result of scale variation of the structure should be considered. Previously, lightweight buoys were used, primarily for cost effectiveness. However, now that floating systems require more than 20 years of durability, concrete buoys must be considered to satisfy this requirement, as well as safety and economic requirements. Therefore, to develop an optimal buoy design, a parametric study of the buoy size constituting the structure should be followed.

In this study, we utilized a multibody analysis and an elastic beam analysis method to investigate the effect of buoy size on responses of the floating structure for offshore sunlight generation systems. Related works regarding multibody analyses have been previously carried out. An analytic study on the wave-induced motion of two ships was performed by strip theory (Fang and Kim, 1986), and an interaction theory for multiple bodies in waves was proposed by Kagemoto and Yue (1986). Later, an analysis on the hydrodynamic interaction of multiple bodies using the panel method was performed (Newman, 2001). In addition, the hydrodynamic interaction of the two floating structures was analyzed via the higher-order boundary element method (HOBEM) (Choi and Hong, 2002). Feng and Bai (2017) applied a fully nonlinear potential theory to perform a hydrodynamic analysis on two bodies. Furthermore, numerous studies have also been carried out on the hydroelastic analysis considering both hydrodynamic and structural problems. For example, the Mega-Float and Mobile Offshore Base (MOB) projects were conducted by the Japanese Technical Research Association and the U.S. Navy, respectively (Rognaas et al., 2001; Shuku et al., 2001). A semi-submergible type of VLFS (very large floating structure) composed of a large number of floats was numerically interpreted (Goo and Yoshida, 1990). Wang et al. (1991) proposed a simplified method for hydroelastic analysis by using a rigid module-flexible connector model. Kashiwagi (1998) introduced a B-spline Gelerkin scheme for calculating the hydroelastic response of VLFS in waves. Murai et al. (1999) proposed numerical methods for VLFS analysis based on an interaction theory to accelerate accurate and efficient computation. An integro-differential equation method for the potential, structural deflection and free-surface elevation for solving hydroelastic problems was developed by Andrianov (2005). Kim et al. (2014) proposed a hydroelastic design contour for the preliminary design of VLFS. In addition, the studies on the hydroelastic response or the hydrodynamic interaction of floating structures, considering a mooring or connection system, were performed (Koo and Kim, 2005; Kim et al., 2007; Riyansyah et al., 2010). VLFS and its applications, research, and development have been

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